Remarks/Arguments

I have responded to the examiners request to remove the informalities, and recast my claims in the form of a single sentence.

I have also attached the correct Oath/Declaration Form filled out and signed.

I have attempted to clarify the benefits of the claimed system. Over the prior patented art. I claim a single heat transfer loop filled with an automotive type antifreeze/water mixture, consisting of the solar collector: a double walled, screw into your existing hot water tank heat exchanger; a circulation pump; a radiator (or air vents) /pressure/temperature regulating system; and tubing to connect the pump, solar collector, pressure/temperature regulator and heat exchanger together.

The system I claim:

1. Uses an antifreeze fluid on the solar collector loop, some prior art cited uses potable fresh water which will freeze if not drained out of the solar collector or heated by flowing warm water into the solar collector;
2. Uses a single one-speed pump to circulate antifreeze fluid, some prior art cited uses two pumps and variable speed pumps which are more costly;
3. Uses a double walled in hot water tank heat exchanger to safely isolate antifreeze fluid from potable water; some prior art cited uses single walled heat exchangers can only be used to separate potable liquids from potable water or no heat exchanger at all;
4. Uses the home's existing hot water tank store solar heated potable water, some prior art cited that users added tanks at added cost;
5. Uses a pressurized antifreeze fluid at about 14 PSIG pressure, some prior art cited uses city water pressure and higher pressure pop-off valves;
6. Uses the pressure generated by the solar collector boiling at about 265°F to activate airflow louvers in solar collector or a steam-condensing radiator, some prior art cited uses temperature activation devices, expanding wax, bimetals, electronic temperature sensors controlling actuators, no one recites using system pressure;
7. Uses an insulated umbilical composed of pipe covering, closed cell rubber insulation, fluid flow tubing and wiring that is put in place on site or prefabricated to go from the solar collector to the hot water tank which remains weatherable after assembly. Prior art cited shows extrusion of all of the parts as one assembly and insulated pipe wraps based on wet fabric placed over fiber insulated pipes to resist fire when dried and hardened. These fabric coatings are not water resistant and cannot be placed in outdoor environments.

In order to help clarify these differences from the patents cited against my system I have constructed the following table, where N/R means Not Recited:

Patent	1. Freeze Protection	2. Pump-ed Loops	3. Heat Exch-anger Walls	4. New Tanks Needed	5. Solar collector Loop Pressure	7, Over Temp./ Pressure Protection	8. Umbilical
Butler	Antifreeze/ Water Fluid	1	2	0	14 PSIG	Liquid to Air radiator & Pressure relief/ Vacuum refill or Pressure activated vents	Assembled from water & sun resistant metal & plastic parts
US-4,557,252 Dinh	Warm water bleed through Solar collector	1	0	0	City about 50 PSIG	N/R	N/R
US-4,399,319 Zinn	None Recited	N/R	N/R	N/R	N/R	N/R	Extruded as one piece.
US-4,282,857 Pei	Drain water from solar collector	2	1	2	70 PSIG Pop off valve	Pop-off valve	N/R
US-4,269,167 Embree	Drain water from solar collector	1 or 2	1	1	City about 50 PSIG	N/R	N/R
US 4,219,009 Palmer	N/R	N/R	N/R	N/R	N/R	Temperature activated vents (wax)	N/R
US 4,043,0317 Scharfman	N/R	N/R	N/R	N/R	N/R	Temperature activated vents (Bimetal, valves, electronic actuators.)	N/R
US-	N/R	N/R	N/R	N/R	N/R	N/R	Cloth

1,959,302 Paige							wrap for insulation & fire proofing
JP-61-122457A Nakakoshi et al	Water or Water/ antifreeze	1 Variable speed	1 or 2 not stated	1	Pressurized	Variable speed pump controller, no protection if pump shuts off.	N/R
JP-59-93149A Goto	Water or Water/ antifreeze	1	1 or 2 not stated	0	Atmospheric Un-pressurized	Liquid to Air radiator	N/R

US- 4,557,252 Dinh recites a system which pumps city water through the solar collector and has no heat exchanger in the water tank. He also recites a valve to let warm water from the hot water tank pass through the solar collector through a bleeding valve to a drain to keep the solar collector from freezing. This is called an open loop system. I have recited a closed loop system, where antifreeze/water mixture circulates through the solar collector, which will not freeze until –54°F. I do not circulate fresh water through the solar collector. I also have a double walled heat exchanger between the antifreeze/water mixture and the potable hot water in the hot water tank.

US- 4,399,319 Zinn recites a flexible umbilical where the tubes and wires are extruded together to form a composite flexible umbilical. I claim the same parts that Zinn uses except I don't put them together as an extrusion. I allow the fluid tubes to be run from the solar collector to the hot water tank heat exchanger, then tied together with polymer separators spaced out at 10 to 15 tube diameters apart, then covered with a closed cell rubber foam or similar insulation, which is split so it can be placed around pipes and adhesively bonded back together to form an insulating tube. The wire running from the solar collector to the controller at the hot water tank is then attached to the outside of the insulation. A suitable weather and UV protection is then used to cover the umbilical, which is split 2 inch ABS pipe, which can be snapped back together is good for this.

US- 4,282,857 Pei recites a closed loop drain back system which drains the solar collector completely, so no water will be left in the solar collectors to freeze at night. This system uses a second pumped water loop and a single wall heat exchanger (60) to take heat from the drain back tank (54) to the hot water tank, not shown in Figure 1. Pei recites a system needing two pump, one for the solar collector loop and one for the heat transfer from his drain back tank (54) to the hot water tank. Pei recites a single wall heat exchanger, since he has potable water in his drain back tank and hot water tank, meaning leakage of solar collector fluid to the hot water tank is not dangerous. I claim a heat

transfer loop full of antifreeze, which does not need to be drained from the solar collector during freezing conditions. I also claim a double walled heat exchanger directly in the hot water tank, which requires only one pump to circulate the fluid from the solar collector to the hot water tank heat exchanger. My system does not require a drain back tank.

US- 4,269,167 Embree recites a closed loop pressurized drain back system. He recites a sump tank, Fig.1 (4) and a single wall heat exchanger into the hot water tank (16) and a single pump (6). Embree also recites a second pump in Figure 5 (92) to pump to external sources via a tube in shell heat exchanger, which is single walled. I claim a heat transfer loop full of antifreeze, which does not need to be drained from the solar collector during freezing conditions. I also claim a double walled heat exchanger directly in the hot water tank, which requires only one pump to circulate the fluid from the solar collector to the hot water tank heat exchanger. My system does not require a drain back tank or single walled in-tank or tube in shell as Embree recites. My main claim 1 was rejected as being anticipated by Embree. His patent does not anticipate my double walled in-tank heat exchanger, antifreeze fluid or pressure relief/ vacuum fill system.

US-4,219,009 Palmer recites a wax based thermal actuator that operates a set of vents to allow air to circulate over the panel to keep it from overheating. Palmers actuator responds only to temperature. I claim a similar set of vents that are activated by the pressure inside the solar collector fluid loop. I claim pressure activation, where the antifreeze/ water mixture ratio and the spring resisting the fluid pressure set the vent opening temperature.

US-4,043,0317 Scharfman recites vent activation (Para.25) "by means of bimetallic, valve-type, or other thermostatic devices directly actuated by the solar collector plate temperature or by means of a temperature sensor attached to the solar collector plate which signals for actuation of the vents.", Scharfman like Palmer recites thermal actuators only that operates a set of vents to allow air to circulate over the panel to keep it from overheating. Scharfman's actuators respond only to temperature. I claim a similar set of vents that are activated by the pressure inside the solar collector fluid loop. I claim pressure activation, where the antifreeze/water mixture ratio and the spring resisting the fluid pressure set the vent opening temperature.

US-1,959,302 Paige recites a fabric coated with a liquid composition which is wrapped around the pipe or pipes (tube or tubes) to insulate them. The fabric is applied wet, and when dried forms a durable stiff, not flexible, fireproof protective cover for indoor plumbing of hot water or steam piping to radiators. The systems Paige recites are not outdoor weatherable and indeed, water can soak back into the fabric insulation, rendering it a good thermal conductor. I claim an umbilical system which is outdoor weatherable, does not absorb water and remains flexible, but is not fireproof, like Paige's system.

JP-61-122457A Nakakoshi et al. recite a closed loop pressurized system with boiling control based on measuring both temperature and pressure in the heat transfer fluid and using these measurements to control pump speed. They also have a liquid, gas separator tank in front of the variable speed pump, to keep it from sucking gas. They do not specify water or antifreeze mixture. They do not specify single or double walled heat exchangers inside the hot water tanks. They show the heat exchanger horizontally near the bottom of the hot water tank. I claim a single speed pump with a double walled insertable heat exchanger into existing hot water tanks, which is inserted from the top of the tank. I claim no liquid gas separator tank is needed in front of my single speed pump. I claim a system that is protected from over temperature and pressure, even it the electric power is lost. Nakakoshi's system will over temperature and overpressure if a power failure occurs on a sunny day.

JP-59-93149A Goto et al. recites an unpressurized heat transfer loop from solar collector to the in water tank heat exchanger. They do not specify water or antifreeze mixture. They do not specify single or double walled heat exchangers inside the hot water tanks. They show the heat exchanger horizontally near the bottom of the hot water tank. The drawings clearly show a vent to the atmosphere. There system looks very similar, but is unpressurized, so even a 50/50 water/antifreeze mixture would boil at 225°F , which is much lower than the 265 °F I claim using 14 PSIG pressure. Goto et al. recites a radiator to control boiling, but has no pressure relief/vacuum refill as I claim.

Applicant respectfully request that a timely Notice of Allowance be issued in this case.

Respectfully Submitted,
Barry L Butler
Dr. Barry L. Butler
Tel: 858-259-8864

United States Patent Application

Docket Number: 10/085,175

Dr. Barry Lynn Butler
980 Santa Estella
Solana Beach, California 92075
SS# 156-34-3255

Date of Filing: 2/27/ 2002
Federal R&D: None
Assignment: None
Related Applications: Internal Water Tank Solar Heat Exchanger – 10/085,174

SOLAR HEAT TRANSFER SYSTEM (HTPL), High Temperature Pressurized Loop

BACKGROUND OF INVENTION

This invention pertains to collection and delivery of heat from a roof or ground mounted solar collector panel to a hot water storage tank via the use of a pressurized fluid loop and a single pump. The pressurized loop system utilizes a water/-antifreeze mixture or other suitable fluid and is circulated via a pump. In addition, the system is protected from over-temperature and over-pressure if the circulating pump ~~fails~~power is lost or the controller turns the pump off. The high temperature fluid heat transfer loop allows for a smaller heat transfer area and hence more compact, hot water tank heat exchanger which adapts to existing hot water tanks and is double walled to prevent cross contamination of potable water and the antifreeze heat transfer fluid in the solar collector loop. ~~and a~~The system includes a small diameter, i.e. ~~approximately~~ 2 ~~Inch~~ inch~~diameter~~, flexible insulated umbilical containing both electrical and ~~fluid tubing connections,~~ approximately ~~¼~~-3/8 inch outside diameter fluid tubing, to go ~~to and from~~between the hot water tank ~~to~~ and the solar collector for ease of installation. The saving in both complexity and

materials for heat exchangers, piping, insulation, and the self-protection from freezing, overheating and over ~~,~~pressure, ~~make~~makes this ~~collector~~solar collector system unique.

PRIOR ART

Most common solar collector systems are un-pressurized and use a heat exchanger external to the water tank to exchange heat from the un-pressurized solar loop to the city water pressure in the hot water tank. Un-pressurized ~~collector~~solar collector heat transfer loops are limited to the boiling point of water/~~-~~antifreeze mixtures, typically 50/50, at atmospheric pressure ~~of~~ which is approximately 220 degrees Fahrenheit. A water antifreeze mixture of approximately 50/50, pressurized to fourteen PSI~~,~~ (or approximately two atmospheres) in the ~~collector~~solar collector loop will not boil until 265 degrees Fahrenheit. The higher operating temperature in the ~~collector~~solar collector loop allows for ~~efficient~~ smaller surface area internal tank heat exchangers to be utilized~~,~~ ~~which~~, which do not disturb the normal tank stratification. Using an ~~Internal~~ internal tank double walled heat exchanger also eliminates the pump ~~would circulate water~~ from the hot water tank through the external heat exchanger. Circulating water from the hot water storage tank, through the external heat exchanger ~~The~~ disturbs the stratification of the ~~normal~~ hot water tank, hot on top and cooler on the bottom~~, is disturbed by circulating water from the hot water storage tank, through the external heat exchanger~~. It is important not to disturb the normal tank stratification~~,~~ because it decreases the normal gas or electric heater efficiency.

Some solar collectors use ~~C~~city ~~line~~ water pressure and flow ~~this~~ the potable city water through the collector to heat it. If the solar collector is in a freezing environment then the potable water must be drained to prevent freeze damage to the solar collectors. There are two methods of freeze protection for potable water in solar collector systems. The first method is to drain all of the water out of the solar collector during freezing

conditions and second method is to supply heated water to the solar collector to keep the solar collector from freezing. The first method of freeze protection by draining the solar collector system includes two approaches, drain down and drain back. Drain down systems use a special "spool" valve to shut off the solar collector supply water and send the collector water down the drain. The drain back systems have a separate solar collector fluid sump tank near the hot water tank. When the pump shuts off the fluid drains from the solar collector into this sump tank inside the home to prevent freezing. The second method of system freeze protection heats the solar collector water using electrical resistance heating elements external or internal, as integrated solar collector storage systems do, or provide heat by bleeding a small amount of hot water from the hot water tank through the solar collector continuously to keep it from freezing. Both of these types of heat adding systems must sense freezing conditions and take appropriate actions, which supply heat that costs money. Hence they are not freeze proof, as are antifreeze/water filled systems. ~~These systems are called integrated collector storage, roof mounted systems. The city potable water is subject to freezing and must be heated electrically at night to keep the collector from freezing during cold weather. Other systems, which circulate potable through the collectors when they're illuminated by the sun, must drain this water out at night during freezing weather.~~

Main advantages of the invention using the pressurized antifreeze/water fluid loop are : 1) ~~Pressurized~~ pressurized water/antifreeze heat transfer loop ~~Allows~~is freeze proof and- allows the solar collectors to operate up to 265 degrees Fahrenheit; 2) ~~Pressurized~~ the high temperature heat transfer loop-_allows heat to be transferred with very low fluid flow rates minimizing pumping power and allowing small diameter tubes to take fluid to and from the solar collector and water tank heat exchanger; 3) ~~Internal~~ internal double walled heat exchanger adapts to existing tanks with minimum re-plumbing and without tank removal or draining; ~~2~~4) ~~Heat exchanger is efficient~~the fluid radiator, pressure relief, vacuum relief, overflow recovery system limits both solar collector temperature and fluid pressure while keeping the system full of fluid and keeping air out of the system to

minimize corrosion; ~~3~~5) ~~Double~~ double wall heat exchanger safely separates toxic heat transfer fluids from potable water; ~~4~~6) ~~This~~ this solar system ~~costs less~~has only one pump and is easier to install and maintain than two tank, two pump systems; and ~~5~~7) ~~Solar system~~The double walled internal hot water tank heat exchanger -maintains normal tank stratification, maintaining the backup electrical or gas system efficiency.

SUMMARY OF INVENTION

In summary, the present invention is a ~~Pressurized~~ pressurized fluid loop, where heat is collected in a solar panel illuminated by the sun, heats a solution of water based antifreeze or other suitable liquid, the fluid is pumped at low flow rate to a hot water tank where it gives up the heat via an internal heat exchanger, then returns to the solar collector at a low flow rate in small tubing. The fluid loop is pressurized and operates above the normal boiling point of water, 212 Fahrenheit, and automatically eliminates air from the heat transfer fluid loop. The fluid loop also has built in over-temperature and over-pressure protection ~~built in~~, so if the fluid circulation pump stops, ~~that~~ the ~~system~~ solar collector will not get too hot and damage ~~itself~~itself.

The primary objective of the present invention is to reduce the amount of material and complexity needed to collect and transport solar heat. This is accomplished ~~buy~~ increasing the temperature in the fluid loop which allows more heat to be stored in each unit volume of fluid in the solar collector heat transfer loop~~, which decreases the area of the hot water tank to fluid loop heat exchanger surface~~. ~~The higher fluid temperature difference, between the hot water tank and the solar collector allow more heat to be stored in each unit volume of fluid in the solar collector heat transfer loop.~~ Hence a smaller volume of fluid~~,~~ at a lower flow rate~~,~~ is needed to deliver the heat from the solar collector to the hot water tank. The higher fluid temperature difference between the hot water tank and the fluid loop, decreases the surface area required for heat exchange inside of the hot water tank. The higher fluid loop temperature in the ~~collector~~solar collector

~~will~~ lowers the collector's efficiency by losing heat to the outside air. Flat plates lose more efficiency than evacuated tube solar collectors~~, since it is loosing heat to the outside air~~. This efficiency loss is ~~a small price to pay~~tolerable for a system using significantly less material.

Another objective is to reduce the time and complexity of retrofitting solar energy to existing homes~~,~~. ~~since it~~ The present invention uses flexible small diameter tubing to carry the low fluid flow volume. The small diameter of the fluid carrying tubes, approximately ~~¼~~ 3/8 ~~Inc~~ inch outside diameter, also allows ~~them~~ the tubes to be thermally insulated and still be less than 2 inches in diameter when bundled together. By adding an electrical wire bundle to the insulated fluid carrying tubes and ~~wrapping~~ placing them ~~with~~ in a protective clam-shell covering, i.e. split pipe, an umbilical ~~cord~~ is created, which carries all fluids and electrical signals from the hot water tank to the solar collector. This "plug and play" umbilical allows ~~for~~ do-it-yourselfers ~~or~~ and professionals to install the system more quickly. These fluid carrying tubes can be installed in existing buildings, because they are flexible and can be fed into and through attics, walls ~~and~~ or placed on the outside of buildings~~, without being unsightly~~.

Additional objectives, advantages and novel features of the invention will be set forth in part in the description which follows and in part will become apparent to those skilled in the art upon examination of the following. Others may be learned by practice of the invention. The objectives and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the pressurized loop solar collector system, including the fluid loop, the solar collector, the hot water tank heat exchanger, the fluid pump, fluid radiator, pressurization, overflow/recovery system, air elimination system and controller

~~and~~. ~~the~~ The boiling activated radiator over-temperature ~~over-pressure~~ and pressure activated over-temperature systems are shown schematically.

FIG. 2 is a view of the boiling activated radiator solar collector ~~over-pressure~~ temperature limiting system and ~~its associated~~ fluid pressurization, overflow/recovery system~~, with the external fluid recovery system~~.

FIG. 3 is a pressure activated solar collector over-temperature control system, ~~which~~ which upon loop boiling opens dampers in the solar collector to ~~let heat out~~allow air-cooling~~, when the fluid in the loop boils and raises the loop pressure~~.

FIG. 4 shows the details of a gas/liquid separator for the ~~is a~~ boiling activated radiator solar collector over-temperature ~~control~~ system, which upon boiling forces steam and fluid from the main fluid loop into a liquid to air heat exchanger-, a radiator~~, to~~, where it is cooled ~~let heat out of the fluid loop, when the fluid in the loop boils~~.

FIG. 5 is a plot of air valve position versus pressure in the solar collector fluid loop.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention (FIG. 1) consists of a pressurized heat transfer loop (1, 14 & 17), which operates well above the boiling point of water at one atmosphere of pressure, 212 degrees Fahrenheit ~~(FIG. 1)~~. The ~~water~~ heat transfer fluid (13) is heated~~,~~ in the solar collector tube (1) by the sun. ~~, in the~~The solar collector (2) can be single~~,~~ or ~~double glazed~~double-glazed. ~~, solar collector (1)~~The heated fluid then exits the solar collector in tube (1) and comes to a three-way connection. Path one (7) goes to the pressure actuator (6), which can move actuator arm (5) to actuate air dampers with motion (4). Path one may not be needed if the path two radiator is sufficient to prevent overheating. Path two

goes through a radiator (8) with fins (9) to a pressure relief valve (10) which includes a vacuum recovery valve to let expelled heat exchanger fluid (13) back into the system from the fluid overflow/recovery reservoir (12), while excluding air. Path three (14) is the fluid tubing leading to the hot water tank (22) heat exchanger (16). The insertable, internal double walled heat exchanger screws into the tank through a tank port (24) and provides water tank fluid (30) ingress or egress via a side port (26). The inside of the outer heat exchanger wall (16) is in physical contact with the outside of tubes (14 &17). Physical contact means that over a significant area or approximately 50% of the surface, the interfaces are compressed together mechanically so heat can cross the interface, but leaking liquid from either side will move along the interface. Tube (14) turns around in the bottom of the heat exchanger and becomes tube (17) exiting the heat exchanger. Tubes (14 & 17) are much hotter than the water in the hot water tank (30) and are in physical contact with wall (16) so the heat is transferred from heat transfer fluid (13) through the first wall (14 or 17) then through the mechanical interface to the second wall (16) then into the water (30). Once tube (17) leaves the heat exchanger it returns to the pump (20) inlet where the fill/drain valve (18) is attached. On the upper side of the pump tube (17) intersects the purge valve (19), which allows the system to be filled with fluid (13), using valves (18, 19 & 21). Tube (17) then returns to the solar collector tube (1) for heating of fluid (13).

To transport the pressurized fluid and the heat it contains from the solar collector to the hot water heater a flexible insulated umbilical is used (15). The umbilical consists of thermally insulated fluid connections (14 & 17) from the solar collector (1 & 2) to the hot water tank, rubber closed-cell thermal insulation (32), the low voltage electrical connections and a weather resistant covering of polymer pipe (31), i.e. ABS, which is split in half so it can be "clam-shelled" over the entire umbilical making one easy to install umbilical length. The two small diameter tubes (14 & 17) containing the solar collector heated fluid (13) are tied together along their length with plastic ties, i.e. "Zip Ties", or a polymer tape or coating to separate them. This allows the two-tube bundle to be flexible and insulated with about ¾ inch thick insulating jacket (32) and still be less

than 2 inches in diameter. Adding a wire cable (34) to the outside of the umbilical allows sensor (50) to be easily connected to the controller or by adding wire cable (62) to the outside of the umbilical allows PV panel (60) to be connected to the pump (20) via the thermal cut off switch (64). The small diameter copper tubes are connected together with standard tubing unions, angles and T-connectors of about 3/8 inch size.

The system has two possible configurations for activating the heat transfer fluid pump (20). The first is a differential temperature control system run from household 115VAC power. This control system has a control box (52), which plugs into the wall outlet, has two low voltage input temperature sensors and an output needed to turn the pump on and off. When the solar collector temperature sensor (50) is hotter than the sensor (56) at the bottom of the hot water tank the controller turns the pump on. When the solar collector (sensor 50) is colder than the hot water tank (sensor 56) the controller turns the pump off. Sensor (56) also tells the controller the tank is getting too hot, ie if no one is home to use hot water, then the controller will shut the pump off even if the sun is shining. This would now cause the radiator (8 & 9) to protect the solar collector from over heating.

The second pumping system is based on using a photovoltaic array (60), which provides 12 Volt power when the sun is shining. This power is carried down to the pump on the umbilical connector wire (62). The pump is a DC powered pump, which is capable of low flow at modest pressures. There is no control box. When the sun is out the pump runs, when it is not, the pump stops. A thermal disconnect switch (64) is placed near the top of the hot water tank (22), so if the water gets too hot switch (64) will disconnect the pump.

~~, an integral part of the collector is a set of damper, which are opened by pressure (15). These dampers are only open when the solar heat collected is more than the hot water tank can use. These dampers when opened allow outside air of less than 120 degrees Fahrenheit to flow over the absorber plate, where the sunlight is converted to heat and transferred into the heat transfer fluid. This airflow cools the absorber and stops the boiling. Then the dampers close and the absorber heats back up. The dampers open~~

~~and close on a 2 to 5 minute cycle and only minor boiling is allowed to take place. This self-controlling feature is unique and allows the collector to protect it self, even if the fluid flow in the pressurized loop (17) stops. Alternatively to the dampers, or along with them one could use the system shown in (Fig 4, (29)), which is a pressurized side channel to the main pressurized heat transfer loop, which is at the uppermost point in the main fluid loop. As gas bubbles form in the solar collector they try to escape by going into the side channel heat exchanger. The fluid there is below the boiling point of the pressurized fluid and they collapse and condense. The fluid is the side channel is cooler, because the outer surface is exposed to the outside air. If no bubbles are forming in the solar collector, then there is no flow of fluid in the side channel and the fluid the side channel stays cool.~~

~~The system has two possible configurations for activating the heat transfer fluid pump (12). The first is a conventional control system run from household 115VAC power. This control system has a control box (11), which plugs into the wall outlet and has three sensors. The collector has a temperature sensor using low voltage (8) who's electrical wires are part of the umbilical, to tell the controller, which turns on the pump, when the collector temperature exceeds the hot water tank temperature, measured by sensor (10) at the bottom of the hot water tank. There is also a sensor in the top of the tank (9), which tells the controller the tank is getting to hot, ie no one home to use hot water, then the controller will shut off the pump. This would now cause the pressure damper or side channel heat exchanger to protect the collector from excessive boiling, which will block the collector tubes with scale in time.~~

~~The second pumping system is based on using a photovoltaic array (6), which provides 12 Volt power when the sun is shining. This power is carried down to the pump on the umbilical connector wire. The pump is a DC powered pump, which is capable of low flow at modest pressures. There is no control box. When the sun is out the pump pumps, when it is not, the pump stops. A thermal disconnect switch (18), is place on the top of the hot water tank, so if it gets too hot, it will disconnect the pump.~~

~~The internal tank heat exchanger adapter (13), screws into the inlet or outlet port of the hot water tank (14) the house water to be heated now exits or enters the tank now via a side arm of the adapter. The pressurized loop heat exchanger fluid enters and exits the adapter in small diameter copper tubing, like quarter inch outside diameter copper tubing.~~

~~To transport the pressurized fluid and the heat it contains from the solar collector to the hot water heater and flexible insulated umbilical is used (7). The umbilical consists of the thermally insulate fluid connections and the low voltage electrical connections in one easy to run length. The two small diameter copper tubes, hot collector fluid to the hot water tank and cooler fluid retuning from the hot water tank to the collector, are held apart by a spacer, such as a polymer coating applied to each, so the can be placed next to each other without touching and tied together along their length. This allows the two-tube bundle to be flexible and insulated with a ¾ inch thick insulating jacket and still be less than 2 inches in diameter. Adding a wire cable to the outside of the umbilical allows sensor (8) to be easily connected to the controller. The small diameter copper tubes are connected together with standard ¼,5/16, or 3/8 unions and T-connectors (5).~~

The invention also consists of a radiator, a pressure relief and vacuum recovery valve and fluid overflow recovery system (Fig 2)~~.~~. ~~and~~ This system includes a pressurized fluid radiator (8) with fins (9) and reservoir (~~3~~12), a pressure_-cap (10) to regulate the pressure in the system~~,~~ and allow the overflowed fluid to return on system cool down at night via the relief valve in (~~2~~10), which is connected to a fluid overflow and recovery reservoir (~~4~~12) via tube (72). The pressure of the fluid in the solar collector heat transfer loop is regulated by the pressure cap, which uses a spring to push against the fluid pressure over a fixed area. During normal daily operation when the sun is out, the heat transfer fluid (13) expands as it heats from 75 degrees Fahrenheit to over 230 degrees Fahrenheit and when the pressure reaches the set pressure, i.e. 16 PSIG, fluid and trapped air overflows to the fluid overflow reservoir (~~21~~12) via tube (72), which is vented to the atmosphere by a cap (~~30~~70). At night, when the fluid in the solar heat transfer system

cools and contracts, fluid only is drawn back through (10) -into the heat transfer system to keep if full of fluid and keep air out. Air in the system ~~increases the~~can cause corrosion ~~of~~ in the fluid loop. This simple system allows the ~~approximately~~ nominal 50~~% water~~ / 50~~%~~ water/antifreeze mixture in the solar heat transfer loop to heat up to over 212 degrees Fahrenheit, without boiling until it reaches almost 265 degrees Fahrenheit, at 16 PSIG confinement pressure. This high temperature allows for heat to be transferred more efficiently into the hot water tank, using lower flow rates and an internal (or external) hot water tank heat exchanger.

The invention also consists of a pressure activated solar collector over-temperature protection system (Fig 3). An integral part of the solar collector is a set of dampers (86 & 88) on both the top and bottom of the solar collector, which are opened by pressure actuator (6). These dampers are only open when the solar heat collected is more than the hot water tank can use. These dampers when opened allow outside air of less than 120 degrees Fahrenheit to flow over the solar absorber plate (Fig1. (3)), where the sunlight is converted to heat and transferred into the heat transfer fluid. This airflow cools the absorber and stops the boiling. Then the dampers close and the absorber heats back up. The dampers open and close on a 2 to 5 minute cycle and only minor boiling is allowed to take place. This self-controlling feature is unique and allows the solar collector to protect itself, even if the fluid flow in the pressurized fluid loop (Fig 1. (1, 14 & 17)) stops. The dampers (vents) can be used together with the boiling activated radiator over-temperature system as shown in Fig 4.

The pressure activated control system is needed if fluid circulation stops for any reason while the sun is shining, i.e. controller turns pump off, pump failure, fluid loop blockage. ~~This~~ The pressure activation system consists of a solar system fluid pressure-activated actuator (~~16~~6), such as a piston (~~22~~84), or other pressure-activated actuator, which is in a retracted state at normal system operating~~atmospheric~~ pressure and in an extended state at the pressure cap relief setting, such as 16 PSIG. A spring (~~20~~82) or pressurized cavity can be used to return the actuator to the retracted state, when the solar

system pressure falls to atmospheric pressure. The solar system fluid (~~21~~13) is sealed into the system via a bellows (~~23~~80) or other acceptable seal, such as an O-ring. The actuator is connected to the fluid loop (~~17~~7).

This actuator output (~~24~~5) is connected to a hinged or sliding valve (~~25~~86~~,~~ or ~~26~~88)~~, like a furnace damper,~~ via a linkage (4), which allows air to flow over the solar collector absorber plate (Fig 1. (3)) ~~and~~ to cool it off with outside air. Over-temperature protection is achieved by successive airflow events over the solar collector absorber plate. When the solar collector gets too hot the heat transfer fluid (~~21~~13) boils in the ~~collector~~solar collector. This causes the pressure actuator to extend and open ~~to~~ the ~~collector air damper valves, which take the heat out of the solar collector and the heat~~solar collector air damper valves, which take the heat out of the solar collector and the heat transfer fluid. This action drops the solar collector temperature below the boiling point and stops boiling. The system pressure returns to ~~atmospheric~~ the set pressure and the actuator retracts and closes the ~~collector~~solar collector air damper valves. This vent open/close cycle -repeats itself until the sun goes down~~,~~ or the fluid flow ~~is~~ ~~reestablished~~resumes. ~~Thus the collector prevents damage to the system, by keeping the collector near the boiling point of the water/antifreeze mixture, if the hot water tank is hot enough, the pump fails to circulate the heat transfer fluid, or the fluid flow path is blocked.~~

~~The inset in~~ Figure ~~3~~ 5 shows that the actuator and air valve position as a function of system pressure. The air valves are shut and the actuator retracted until a pressure of approximately 80% (102) of the maximum system pressure~~,~~ maintained by the pressure cap (Fig.4 (10)) is reached. ~~T~~At pressures above (102) the~~ir~~ air valves ~~are~~ begin to open and ~~the actuator extended by the time~~fully open when the system reaches 95% (104) of the system pressure (104) maintained by "~~the radiator~~pressure cap (Fig.4 (10))". This arrangement allows the system to cool itself before vigorous boiling occurs. The pressure vs. actuator position profile is determined by the piston area (Fig 3. (~~22~~84)) and spring (Fig 3. (~~20~~82)) constant.

Figure 4 shows ~~The invention also consists of a~~a boiling activated radiator solar collector over-temperature protection system~~(Fig 4)~~. The system consists of a liquid to air radiator heat exchanger and a boiling gas separator. During normal operation the~~y~~ entire system is full of heat transfer fluid (~~21~~13) and no boiling occurs. The liquid to air heat exchanger (~~29~~8) with fins (9) is a side arm and normally has no fluid flow in it. Normally the fluid flows into the boiling gas separator (94) from the solar collector tube (1) and out of it in tube (14) down to the hot water tank heat exchanger. Under ~~abnormal~~ non-flow conditions, such as circulating pump failure or the solar input being greater than the hot water tank can use, the solar collector will begin to boil. In this event the boiling gas separator (~~28~~94) allows the gas bubbles (steam) to go into the liquid to air heat exchanger (~~29~~8), which stirs the liquid in the heat exchanger, while condensing the boiling gas. ~~and~~ This heat in chamber (8) is conducted to the ~~heats it~~ fins (9), which heats them above outside air temperature ~~and dissipates this heat to the outside air~~removing heat from the fluid in radiator (8). The filler tube (~~27~~92) allows liquid to come from the liquid to air ~~exchanger~~ radiator (8) and be inserted below where the gas bubbles are being released tube (1) in the boiling gas separator (~~28~~94), keeping the collector fluid loop (1, 14 & 17) full of liquid.

The system allows a small amount of boiling to take place~~, which~~, which rejects heat to the atmosphere via the liquid to air radiator ~~their~~ heat exchanger. As long as boiling takes place the liquid in the ~~side arm heat exchanger~~radiator (8) will be heated by condensing the boiling gas. Only a small amount ~~a~~ of fluid (13) will be forced through tube (72) into ~~a~~ the fluid overflow ~~steam~~ reservoir (12)~~condenser (4)~~. The advantage of this system is that it has no moving parts and can ~~easily~~ be made to dissipate all of the heat that the solar collector ~~can~~ gathers from the sun.

ABSTRACT

Delivering heat from modern high temperature solar collectors to a storage tanks is more effectively done using a pressurized, high temperature fluid loop using non-flammable and low toxicity heat transfer fluids and is the subject of this patent. Toxic and Non-toxic water/antifreeze mixtures can be used in pressurized loops~~--~~, i.e. approximately ~~(14#, (~~14 ~~Pounds~~ pounds ~~Square~~ per square ~~Inch~~ inch ~~pressure~~ above atmosphere,~~)~~) ~~systems up~~raising the boiling point to 265 degrees Fahrenheit ~~before the mixture boils~~.-- To achieve a pressurized loop, which automatically eliminates trapped air in a practical manner, a pressurized radiator, a pressurizing/vacuum recover cap and overflow reservoir are used. The system protects itself from loss of fluid flow by ~~Boiling~~ boiling under pressure. ~~transports either steam or heat out of the closed system.~~ The steam ~~must be~~produced is either condensed in a liquid to air radiator and returned to the closed loop system to keep it full, ~~. In order to accomplish this in a practical manner a pressurizing cap and overflow reservoir are used.~~ or ~~The~~ the steam pressure will be used to open vents on the solar collector allowing air to pass over and cool the solar collector.~~system will either shed excess heat collected by boiling or limit the heat input from the collector panel by increasing its heat loss due to increasing solar collector temperature above ambient.~~ Fluid and electrical connections between the solar collector and storage tank are made using a weather-proof insulated umbilical. Heat in the pumped fluid loop is delivered to the existing hot water storage tank by means of an adaptable, internal, double walled, heat exchanger.

Claims

~~1.~~1. (currently amended): A pressurized loop solar collectors system for delivering solar energy from a roof mounted panel to a domestic hot water tank ~~,~~including: a

~~a.P~~pressurization system capable of maintaining system pressures above atmospheric pressure to increase the boiling point of the heat ~~collection~~ transfer fluid~~.~~; a fluid radiator/overflow/recovery apparatus to catch overflow heat transfer fluid and trapped air and return the fluid to the system while keeping air out;

~~b.A~~a ~~means~~ heat transfer fluid to air radiator or solar collector air vents to prevent ~~damage to~~the solar collectors ~~system~~ from overheating during ~~abnormal~~ no flow conditions; an antifreeze heat transfer fluid

~~c.The means~~ to prevent damage from freezing in winter environments; a flexible umbilical to connect solar collector and water tank heat exchanger together; a circulation pump; control system and~~.~~

a\

~~d.A~~a double walled internal heat exchanger which is adaptable to existing hot water tank, ~~means~~ to deliver heat from the heat transfer fluid to the hot water tank ~~with an easily adaptable internal heat exchanger~~.

~~e.A better means to deliver heat to the hot water tank even with an external heat exchanger.~~

~~2.~~2. (currently amended): A boiling activated radiator solar collector over-temperature protection system~~,~~ ~~which~~ which includes a fluid radiator/overflow/recovery apparatus to catch overflow heat transfer fluid and trapped air and return the fluid to the system while keeping air out, utilizes no moving ~~parts~~actuators, and includes ~~.~~

~~a.The~~ a boiling gas/liquid separator, which allows ~~gas bubbles~~steam to ~~heat~~ reach a liquid to air ~~heat exchanger~~radiator and allows condensed water to be returned to the fluid loop.~~.~~

~~b.A filler tube, which allows the gas bubbles to heat the liquid to air heat exchanger, while keeping the system fluid loop full of liquid.~~

3. (currently amended): A pressure activated solar collector over-temperature protection system which utilizes solar collector air dampers as moving parts, including: ~~A~~ a pressure activated mechanical actuator, which opens before the systems regulated pressure is reached; and ~~.~~

~~b. A~~ a set ~~to~~ of damper ~~the~~ valves, which control airflow over the solar collector panel, so when opened the sun's energy is dissipated to the flowing ambient air and when closed the sun's energy is delivered to the fluid loop and hot water tank.

~~4.~~4. (currently amended): A flexible umbilical assembly ~~, which~~that carries and insulates the heat transfer fluid —tubing while protecting it from the elements with a clamp-on "clam-shell" split pipe external covering~~,~~ and includes all electrical connections between the solar collector and the hot water tank.

a, cont.

~~5.~~5. (currently amended): The system ~~in~~ according to claim 1, with a 220/115 VAC controller and pump~~,~~ ~~with~~ and boiling activated over-temperature protection ~~of~~ according to claim 2.

~~6.~~6. (currently amended): The system ~~in~~ according to claim 1, with a 220/115 VAC controller and pump, with pressure activated over-temperature protection ~~of~~ according to claim 3.

~~7.~~7. (currently amended): The system ~~in~~ according to claim 1, with a photovoltaic panel and ~~and~~ low voltage (12VDC) pump, with boiling activated over-temperature protection ~~of~~ according to claim 2.

~~8.~~8. (currently amended): The system ~~in~~ according to claim 1, with a photovoltaic panel and low voltage (12VDC) pump, with pressure activated over-temperature protection ~~of~~ according to claim 3.